

Economics of Alternate Land Use Systems

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Introduction

Increasing productivity in drylands is a prerequisite for accelerating the rate of economic growth with social justice. Dryland farming is characterized by poor soil resources, low and erratic rainfall and low investment capacity of farmers. Coarse cereals and pulses constitute the major crops grown in drylands. The demand for these crop commodities suffer from low income elasticity of demand. Also technological improvements in production of these crops have relatively been slow. Therefore, “land-use options that increase livelihood security and reduce vulnerability to climate and environmental change are necessary” (Pandey, 2007). These factors together are responsible for low returns from crop production in drylands. What is therefore needed is an alternative that meets multiple needs (food, fodder, fuel, etc.) of the farmers and yet less input requiring. Not only these Alternate Land Use Systems (ALUS) offer possibilities to increase income from drylands, they also serve some important environmental functions. In the current scenario characterized by accelerated rates of resource degradation and the imminent and potential adverse effects of climate change on the ecosystems, crop production and livelihoods, the environmental functions of alternate land use systems assume as much importance as their production and livelihood functions.

Some ALUs :

- 1) Agro-forestry
- 2) Agri-horticulture
- 3) Silvi-pastures
- 4) Horti-pastural systems

The choice of a particular ALU is to be made keeping in view the given agro-climatic conditions, availability of the necessary inputs, investment capacity and the available market support.

How are alternate land use systems differ from arable cropping?

ALUs differ from arable cropping in their growth habits (perennial), input requirements, management interventions and output flows. Output from some ALUs (e.g. pastures) serve as inputs to other enterprises (Livestock) and hence need enterprise-integration in order to optimize the income. Systems involving silviculture and horticulture take some years (gestation period) before they start giving economic returns.

The ALUs generally result in production of more than one output and are helpful in meeting multiple needs. These outputs produced within a system may exhibit different relationships – complementary, supplementary and competitive – over time and space. Typically, the relationships remain complementary or supplementary during the initial period before becoming competitive for resources, inputs and management attention. At this point of time decisions have to be made on whether and how much of different components to be produced.

Benefits ALUs

ALUs such as agroforestry provide three types of economic benefits. First, they help in spreading the fixed costs between the outputs being produced from the system. Compared to the production of trees alone, these systems take short time before giving economic returns, i.e. shortening the initial gestation period. The other benefit is that they help spread risk and hence a more stable returns to the farmers. Further, these systems are not so sensitive to the timeliness of operations as the arable crops are and hence do not compete so much with the labour requirements of the crops.

A number of studies assessed the economic performance of different ALUs in comparison with the arable cropping as well as in isolation. Since ALUs are perennial, they require investments and give outputs over years and hence need different techniques for economic evaluation. These techniques essentially consider the timing of costs and benefits into consideration. Net present value, Benefit-Cost Ratio, Pay-Back Period, Internal Rate of Returns and Annuity Values are most commonly used measurements of economic viability.

Alternate Land Use Systems performed better than arable crops. Agri-horticulture (e.g. ber) was most remunerative with a Benefit-Cost Ratio of about 5.00, as against 2.00 in agri-silviculture and 1.2 – 1.75 in case of arable crops. Dryland horticulture crops without any arable crops grown during the initial period gave favourable. Benefit-Cost Ratios of 3.21 in mango, 2.18 in guava, 3.04 in acid lime and 2.89 in sweet lime. However, it should be noticed that favourable IBCR cannot guarantee their adoption. Establishment of these alternate land use systems requires high initial investments and good marketing facilities (Reddy and Sudha, 1989). Also, it may not be possible for small and marginal farmers to take up these systems in their small fragmented holdings, which place them in a disadvantageous position.

Agroforestry could contribute to livelihoods improvement in India where people have a very long history and accumulated local knowledge. India is particularly notable for ethnoforestry practices and indigenous knowledge systems on tree-growing. In terms of household income central Indian upland ricefields provide an illuminating economics⁸⁹. The farms often have an average of 20 *Acacia nilotica* trees per ha. of 1 to 12 years of age. Small farms have more tree-density. At a 10 years rotation, these trees provide a variety of products including fuelwood (30 kg/tree), brushwood for fencing (4 kg/tree), small timber for farm implements and furniture (0.2 m³), and nontimber forest products such as gum and seeds. Thus, trees account for nearly 10% of the annual farm income—distributed uniformly throughout the year than in rice monoculture—of smallholder farmers with less than 2 ha farm holding. The combination of *Acacia* and rice traditional agroforestry system has a benefit/cost (B/C) ratio of 1.47 and an internal rate of return (IRR) of 33% at 12% annual discount rate during a ten- year period.

Consequent to the emergence of carbon trading as a remunerative market for expanding the efforts towards mitigation of climate change, these ALUs, especially systems like agro-forestry, can even play a better role in carbon capturing and converting this into enhanced incomes to the farmers.

Land management actions that enhance the uptake of CO₂ or reduce its emissions have the potential to remove a significant amount of CO₂ from the atmosphere if the trees are harvested, accompanied by regeneration of the area, and sequestered carbon is locked through non-destructive (non-CO₂ emitting) use of such wood. Carbon management through afforestation and reforestation in degraded natural forests are useful options but agroforestry is attractive because: (i) it sequesters carbon in

vegetation and possibly in soils depending on the pre-conversion soil C, (ii) the more intensive use of the land for agricultural production reduces the need for slash-and-burn or shifting cultivation, which contribute to deforestation, (iii) the wood products produced under agroforestry serve as substitute for similar products unsustainably harvested from the natural forest, (iv) to the extent that agroforestry increases the income of farmers, it reduces the incentive for further extraction from the natural forest for income augmentation.

In India, average sequestration potential in agroforestry has been estimated to be 25t C per ha over 96 million ha, but there is a considerable variation in different regions depending upon the biomass production. However, compared to degraded systems, agroforestry may hold more carbon. For example, the above ground biomass accumulation in central Himalayan agroforestry system has been found to be 3.9 t ha⁻¹ yr⁻¹ compared with 1.1 t ha⁻¹ yr⁻¹ at the degraded forestland (Pandey, 2007).

In India, various soil management practices to enhance soil organic carbon content have been suggested including reduced tillage, manuring, residue incorporation, improving soil biodiversity, and mulching. However, a useful path, complementary to chemical fertilizers, to enhance soil fertility is through agroforestry. Alternate land use systems such as agroforestry, agro-horticultural, agro-pastoral, and agrosilvipasture are more effective for soil organic matter restoration. Soil fertility can also be regained in shifting cultivation areas with suitable species. For instance, a field experiment to study the N₂ fixation efficiency suggests that planting of stem cuttings and flooding resulted in greater biological N₂ fixation, 307 and 209 kg N ha⁻¹ by *Sesbania rostrata* and *S. cannabina*, respectively. Thus, *S. rostrata* can be used as a green manure by planting the stem cuttings under flooded conditions.

Through a combination of mulching and water conservation, trees in agroecosystems may directly enhance the crop yields of coarse grains. For instance, in the arid region of Haryana, the effect of *Prosopis cineraria*, *Tecomella undulata*, *Acacia albida* and *Azadirachta indica* on the productivity of *Hordeum vulgare* (barley) was found to be positive. *P. cineraria* enhanced the grain yield by 86.0%, *T. undulata* by 48.8%, *A. albida* by 57.9% and *A. indica* by 16.8% over the control. Biological yield was also higher under the trees than that in the open area. The soils under different tree canopies were rich in organic carbon content, moisture availability and nutrient status.

Constraints to adoption of ALUs

Small size of land holdings offers very little scope to divert land use from production of annual food and commercial crops. The perennial nature of ALUs imparts some rigidity to the enterprise. Unlike with the annual crops, the decisions made with respect to ALUs can not be reversed without significant cost and the land gets locked in for a longer period of time. This, along with high initial investment, forms one of the reasons why farmers are reluctant to switch over to ALUs. However, some ALUs allow growing intercrops during the initial stages when the resources are relatively abundant and the crop and tree components are supplementary or complementary. The most important limitation to popularization of ALUs is lack of proper market support. Not only farmers are not aware of the prevailing prices, they also do not have access to information on where to sell their produce. Knowledge of choice of species and appropriate varieties, their availability, management practices, long gestation period, small farm size are some of other factors that constrain adoption of ALUs. It may be mentioned here that about 10% of the cropped area can be brought under ALUs without affecting the total food grain production in the country.

The environmental functions that the ALUs provide strengthen the economic viability further. In case of tree farming, it has been shown that the gap between financial returns and economic benefits is so high that the government may afford to provide some subsidy (to the tune of about Rs.150-200/ha at 1980-81 prices) to the trees grown.

Participation in carbon markets is also very complex and farmers have to deal with a number of agencies and meet a number of conditions such as Additionality Requirement and 'policy obstacles'. Lack of methodological agreements on quantification of the amount of carbon sequestered or captured is another constraint as it becomes difficult for a farmer to know the size of returns expected from participation in these markets.

Future research on ALUS

Some of the areas demand further research in ALUs are listed below:

- The effect of tree species on the crop yields at different ages of the trees is yet to be fully understood. There are studies which reported increase or decrease in the crop yields in the presence of tree species during the initial years. The effect of fully grown trees on the crop yields may be better studied in longer-term studies. Similarly, further research is needed as to whether the agro-forestry systems will actually increase the availability of nutrients or will only redistribute the available nutrients vertically and horizontally.
- High water use by fast-growing species and therefore alleged groundwater depletion is a common concern in dry regions that remains unresolved. Do trees actually extract more groundwater or use the residual water available either through irrigation, or use the rainwater when crops have been harvested? It may be possible that rather than letting the rains be lost as runoff, agroforestry may increase the utilization of rainwater by extending the growing season. Furthermore, it is not clearly understood if trees harvest and accumulate water from surrounding area and release it during the soil-moisture stress. If this is so then, agroforestry as an adaptation to monsoon variability may actually benefit the crops.
- Studies on the carbon sequestration potential are limited both by their location-specificity as well as uncertainty related to sequestration in biomass and soils. Often, the rate of carbon sequestration is derived from the growth of above ground biomass. Holistic insights are required on the carbon sequestration by agroforestry systems.
- Many species that can be part of ALUs have the potential to improve livelihoods of poor farmers, but efforts are needed to provide knowledge on the on-farm value addition innovation.

Table 1: Economic evaluation of farm-forestry trees (Rs/ha)

Feeling periods of life-span considered (yr)		Present worth at a discount of		Annuity value at a discount of		Benefit-Cost Ratio at a discount of	
		11%	20%	11%	20%	11%	20%
Casuarinas	05	10769	7597	2625	2117	6.76	5.17
	10	19614	12152	3000	2415	11.08	7.52
	15	22448	13110	2812	2336	12.33	7.92
Eucalyptus hybrid	20	15283	7788	1729	1333	17.52	10.43
	30	16716	7988	1741	1337	18.60	10.64
	40	17020	8007	1625	1335	18.76	10.65
Annual crops: Finger millet		1095		1095		1.53	

Table 2: Economic evaluation of agro-forestry system during a 10-year period (data from Hayathnagar Research Farm, Hyderabad, India)

Economic measures	Present values (Rs/ha at a discount of			
	11%		20%	
	Sorghum pigeonpea	/ Castor	Sorghum pigeonpea	/ Castor
Costs	9985	12585	7929	9932
Returns	17260	17009	10530	12028
Net present worth	7275	4424	2601	2096
Annuity Value	1117	667	853	417
Benefit-Cost Ratio	1.73	1.35	1.33	1.21

Table 3: Economic evaluation of agro-horticultural system during a 10-year period (data from Hayathnagar Research Farm, Hyderabad, India)

Period / lifespan (yr)	Net presented worth at a discount rate of		Annuity Value at a discount rate of		Benefit-Cost Ratio at a discount rate of	
	11%	20%	11%	20%	11%	20%
10	99977	63763	15294	12674	5.19	4.58
20	166450	104444	18150	14638	5.90	5.08
30	171728	87461	17881	14638	5.78	5.08

Table 4: Economic evaluation of agro-horticultural system during (data from Hayathnagar Research Farm, Hyderabad, India)

Crop in combination with Leucocephala	Net presented worth at a discount rate of		Annuity Value at a discount rate of		Benefit-Cost Ratio at a discount rate of	
	11%	20%	11%	20%	11%	20%
Sorghum	7870	5741	1204	1141	1.80	1.74
Pearl millet	4041	2783	618	553	1.48	1.42
Castor	15405	11572	2364	2300	2.08	2.03
Pigeonpea	6298	4243	908	843	1.58	1.52

Table 5: Present values of net financial returns and economic benefits and corresponding annuities from raising five tree species on dryland in the hot arid zone of Rajasthan, India

Description	Financial ¹		Economic benefits ¹		Economic ²	
	NPVs	Annuity	NPVs	Annuity	NPVs	Annuity
<i>Acacia tortilis</i>	1860	360	2640	520	3090	580
<i>Albizia lebbek</i>	3940	550	5120	710	6310	780
<i>Prosopis cineraria</i>	14830	1700	17680	2030	24060	2340
<i>Zizyphus</i> sp.						
i) Felling at 15 years	20920	2910	31220	31220	36990	4590
ii) Felling at 25 years	27530	3270	39230	39230	49090	5000
<i>Prosopis juliflora</i>	4040	950	5420	1280	6130	1370

Discount rate = 11%

Discount rate = 9%

Table 6. Income from agroforestry systems in Himalayas

SNo	Typology of tree growing practice	Income (Rs/ha/yr)
1	Home gardens	18200
2	Simultaneous agroforestry	25370
3	Sequential agroforestry	9426

Source: Pandey DN 2007 Current Science 92 (4) 455-467

Table 7. Financial analyses of sole eucalyptus, sole crop and eucalyptus-based agroforestry systems in Andhra Pradesh, India

System/ spacings	Total costs (Rs ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)					Total net returns
			Year1 (2001)	Year2 (2002)	Year3 (2003)	Year4 (2004)	Year 5 (2005)	
Agroforestry systems								
10 x 1.5m (Triple rows)	71737	171178	-7947	3347	2932	700	100509	99441
11 x 1m (Paired rows)	71362	170611	-9693	2077	1690	-32	105204	99246
7 x 1.5 m (Paired rows)	71145	170581	-10095	-431	880	-2246	111360	99468
6 x 1 m	71437	171699	-11493	-1547	-74	-1526	111569	100262
3 x 2 m (Farmers' practice)	70275	157774	-10941	-3965	-4366	-3853	110629	87503
Sole eucalyptus	50671	133553	-23450	-3205	-3205	-3205	115948	82883
Arable cropping	28941	58282	12111	5896	7749	5385	-1801	29340
LSD (0.05)	1543	13426	1345	-	1045	1661	12010	10929

US \$ 1 = Rs 40 (August 2007)

Table 8. Benefit-Cost ratio and Net Present Value for eucalyptus based systems at different discount rates in Andhra Pradesh, India

System / spacings	6%		12%		18%	
	NPV	B:C	NPV	B:C	NPV	B:C
Agroforestry systems						
10 x 1.5m (Triple rows)	73494	2.2	55012	2.03	41669	1.90
11 x 1m (Paired rows)	72690	2.17	53833	2.03	40268	1.86
7 x 1.5 m (Paired rows)	72243	2.17	52981	2.03	39182	1.83
6 x 1 m	72346	2.17	52630	2.0	38585	1.83
3 x 2 m (Farmers' practice)	62074	2.07	44237	1.86	31584	1.66
Sole eucalyptus	56417	2.07	37927	2.03	24900	1.66
Arable cropping	26097	2.3	23435	2.13	21202	2.17
LSD (0.05)	10023	-	7530	-	3836	-